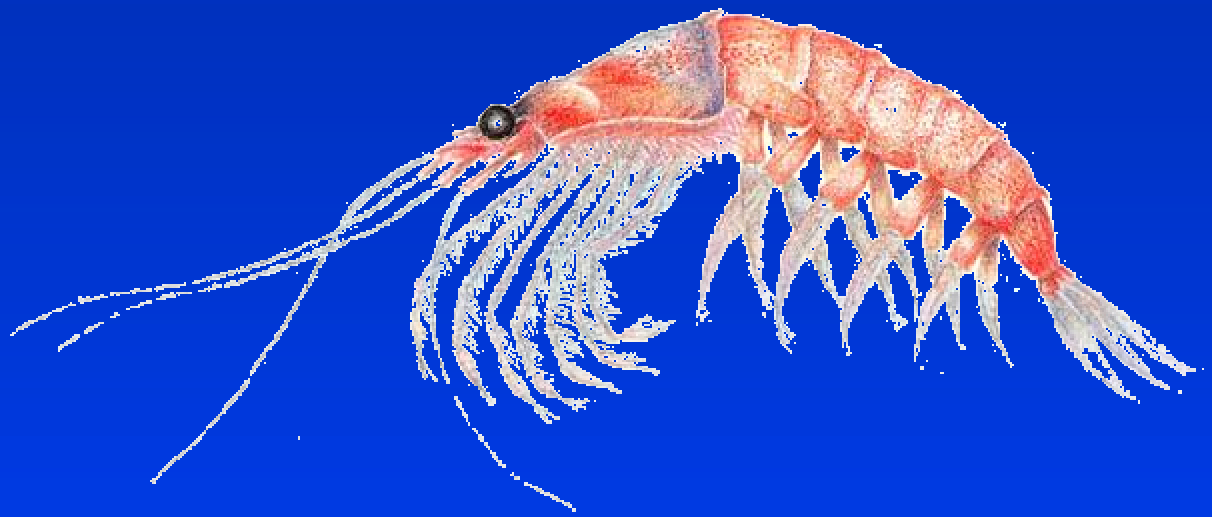
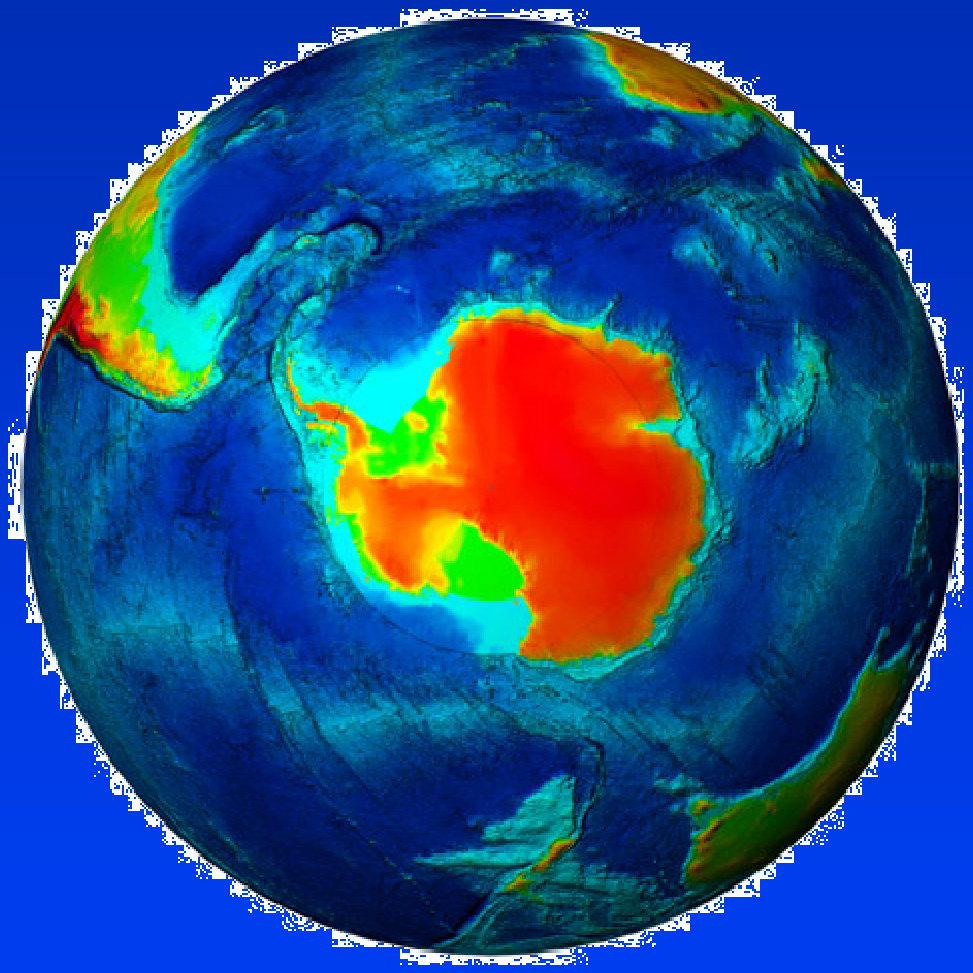
An Ecosystem Approach to Management in the Southern Ocean: CCAMLR and NOAA



Christian S. Reiss
Antarctic Ecosystem Research Division
Southwest Fisheries Science Center
La Jolla, California, USA

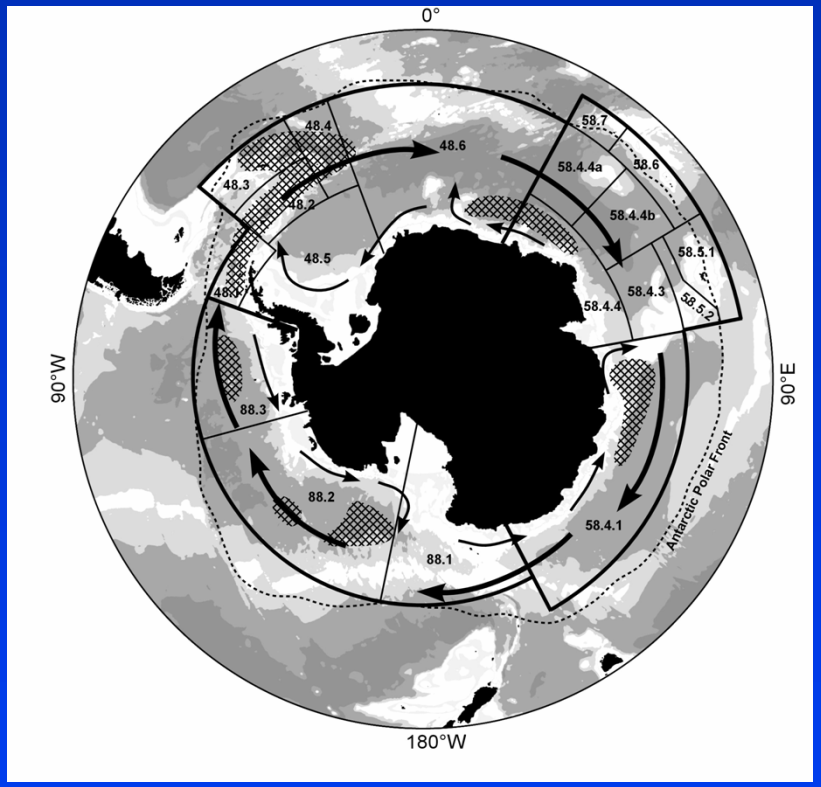
Antarctic Treaty (1961)



- Peaceful use, no military installations or testing of nuclear weapons
- Open access between Parties
- Neither recognizes nor abolishes territorial claims
- 12 original Parties, now 45

- Agreed Measures for the Conservation of Antarctic Flora and Fauna (1964)
- Convention for the Conservation of Antarctic Seals (1972)
- Convention for the Conservation of Antarctic Marine Living Resources (1980)
- Madrid Protocols (1991)

Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)



- Negotiated in late 1970s by Antarctic Treaty Consultative Parties
- 24 Signatory Members plus 7 acceding nations
- Convention boundaries approximate Antarctic Polar Front
- **Competence for all living marine resources except seals and whales**
- **Consensus decision-making procedure**
- Ratified by US in 1984, established US AMLR Program

CCAMLR is a Fisheries Treaty (Article II)

1. **Objective is conservation**
2. **Conservation includes rational use**
3. **Rational use (harvesting) conducted so as to**:
   a. Prevent decrease in size of harvested populations below that necessary for stable recruitment
   b. Maintain ecological relationships between harvested, dependent and related species
   c. Prevent or minimize risk of changes not reversible over two or three decades

And further states:

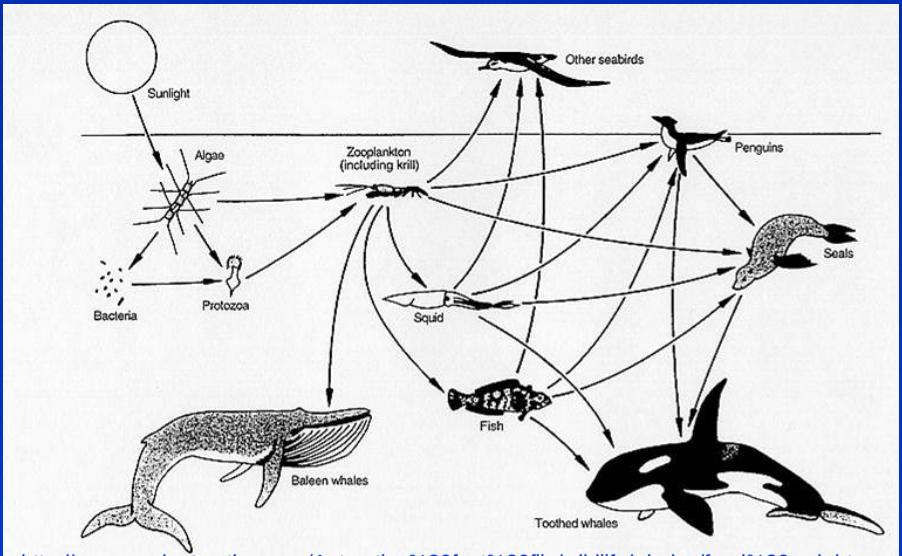
> "… taking into account the state of available knowledge of ***the direct and indirect impacts of harvesting***, the effects of introduction of alien species, the effects of associated activities on the marine ecosystem, ***and the effects of environmental change***, with the aim of making possible the sustained conservation of Antarctic marine living resources."

Significance of Article II

- **Resource management should follow:**
  - –Precautionary approach – in accordance with the mandate to minimize risk of change to ecosystem
  - –Ecosystem approach – in accordance with the mandate to consider both trophic interactions and physical forcing

- **Not defined:**
  - –Risk criteria and acceptable levels of risk
  - –Acceptable and unacceptable levels of ecosystem change
  - –Action required when causes of ecosystem change cannot be unambiguously attributed to either the fishery or the environment

The krill-centric ecosystem

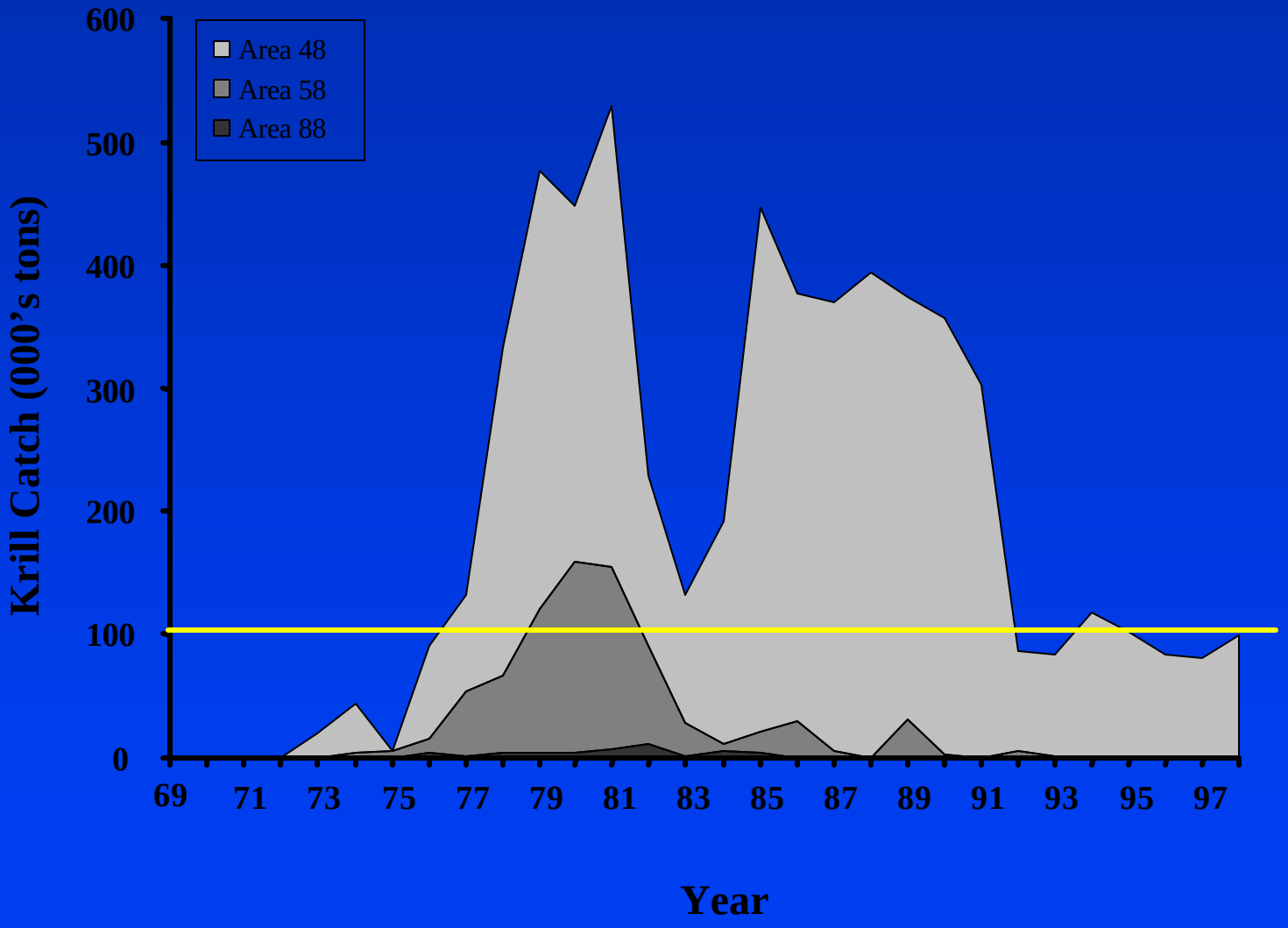


http://www.coolantarctica.com/Antarctica%20fact%20file/wildlife/whales/food%20web.htm

Annual Demand (million tons)

Baleen whales	30 – 45
Seals	120 -150
Penguins / birds	20 - 30
Squid	30 - 50
Fish	10 - 20
Total	**250 ± 50**

Historical commercial catch



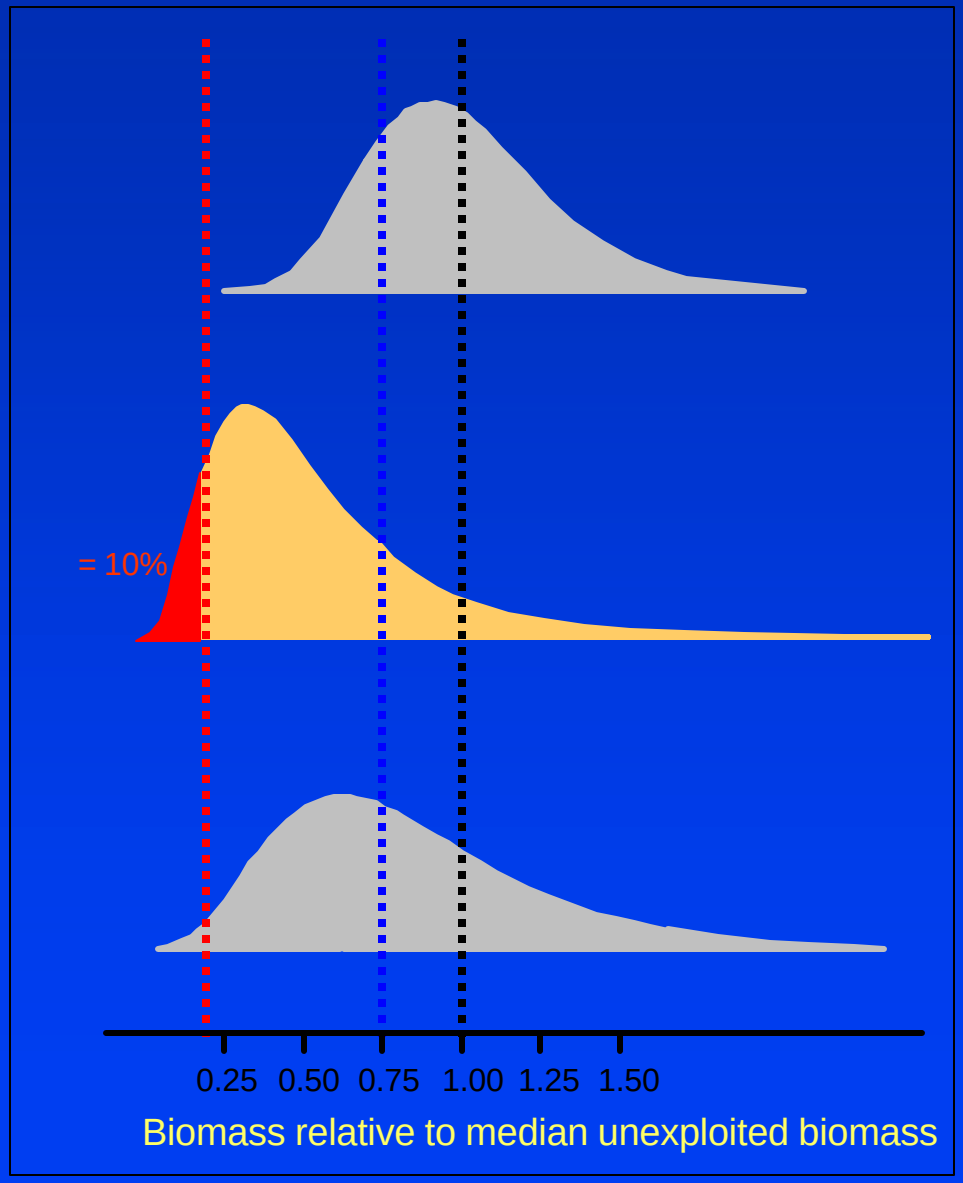
Three basic tasks emerge:

- Assess prey population dynamics
- Monitor predator populations and environmental relationships
- Minimize interactions between fishery and land based foragers

Assess krill population dynamics: Operational definitions from Article II

- **Prevent decrease in size of harvested populations below that necessary for stable recruitment**
  - –Probability that spawning biomass in any one year falls below 20% of unexploited median biomass should be 10% or less
- **Maintain ecological relationships between harvested, dependent and related species**
  - –Median level of spawning biomass should be 75% or greater of unexploited median biomass
- **Prevent or minimize risk of changes not reversible over two or three decades**
  - –Run simulations for a minimum of 20 years

Krill Yield Model



- 1981 FIBEX survey provided first B_0
- CCAMLR 2000 updated B_0 to 44 million tons (recently doubled; Demer and Conti 2005)
- Yield is a proportion of the unexploited population biomass
- $Y = ?B_0$
- Age-structured population simulation model
- PDFs of initial abundance, growth, mortality, maturity and recruitment
- Incorporate both natural variability and measurement uncertainty
- ? = 0.091, Y = 4 million tons
- Approximately 1 million tons allocated to
- 48.1,48.2,48.3
- Current consenus caps catch at 640K tons without Small Scale Management in place

Gulland 1971
Beddington and Cooke 1983
Butterworth et al 1992, 1994
Constable and de la Mare 1996
Constable et al. 2000

Issue is where and when to fish – not how much

Historical maximum catch ~650 Ktons

Current extraction ~100 Ktons during austral summer

Maximum potential removals ~1 million tons

Consensus to expand fishery requires small scale management

Must know predator population trends

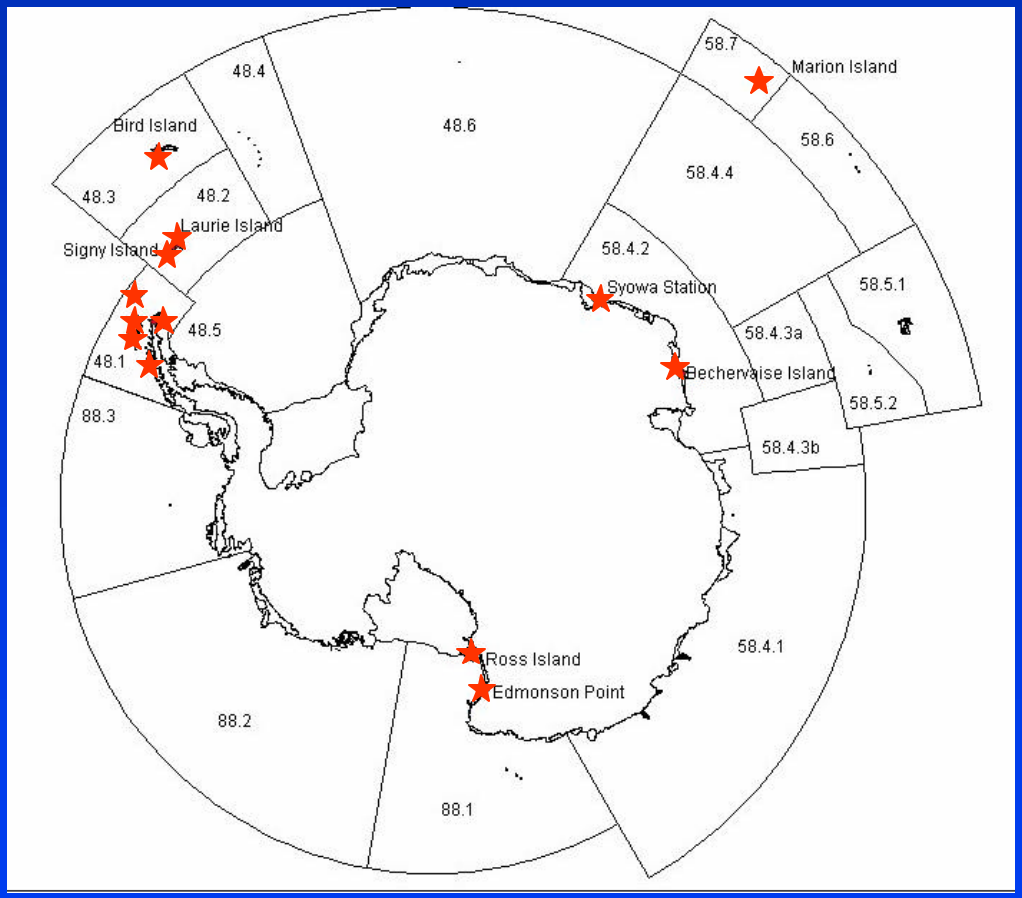
Must know environmental relationships

Must know overlap between predator and fishery

Monitor predator populations: CCAMLR Ecosystem Monitoring Program (CEMP)

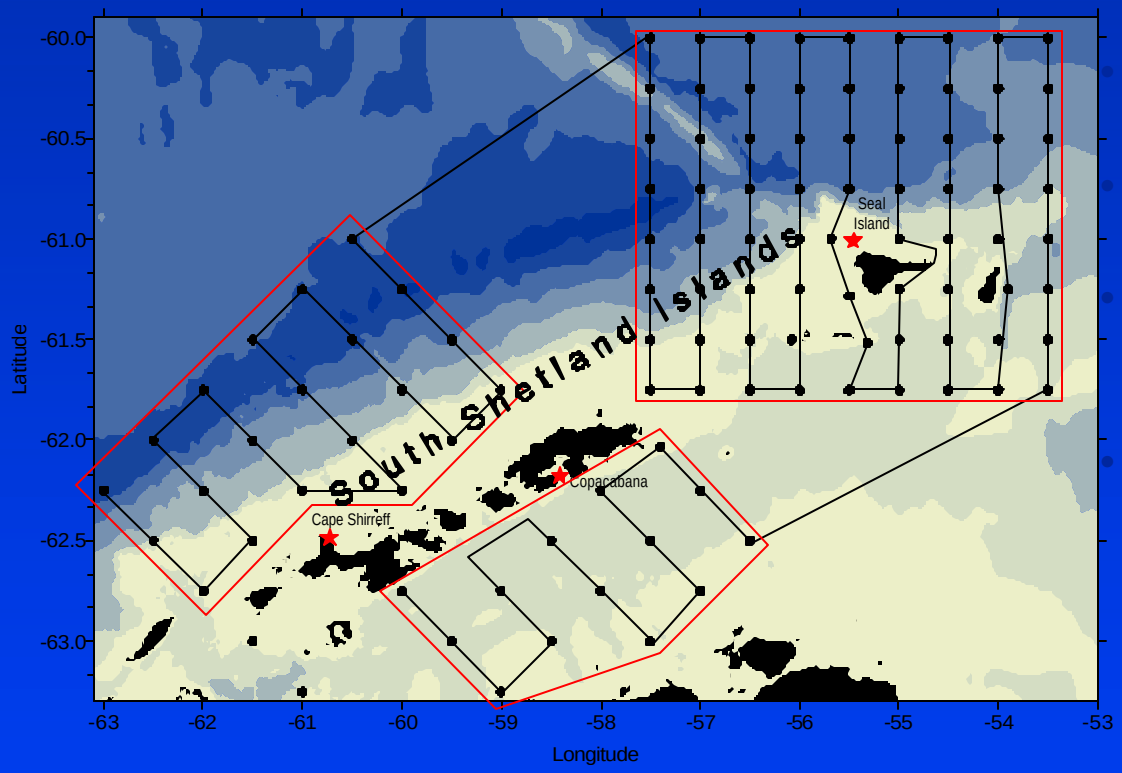
- **Objectives**
  - –Detect and record significant changes in critical components of the ecosystem to serve as a basis for the conservation of Antarctic marine living resources
  - –Distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological
- **Criteria for indicator species**
  - –Feed predominately on krill, wide geographic range, represent important ecosystem components
  - –Crabeater and Antarctic fur seals, Adelie, gentoo, chinstrap and macaroni penguins, Antarctic and Cape petrels, black-browed albatrosses
  - –Indices of reproductive performance, growth and condition, feeding ecology, abundance
- **Environmental indices (sea ice extent, meteorological conditions, hydrographic conditions)**

CEMP sites



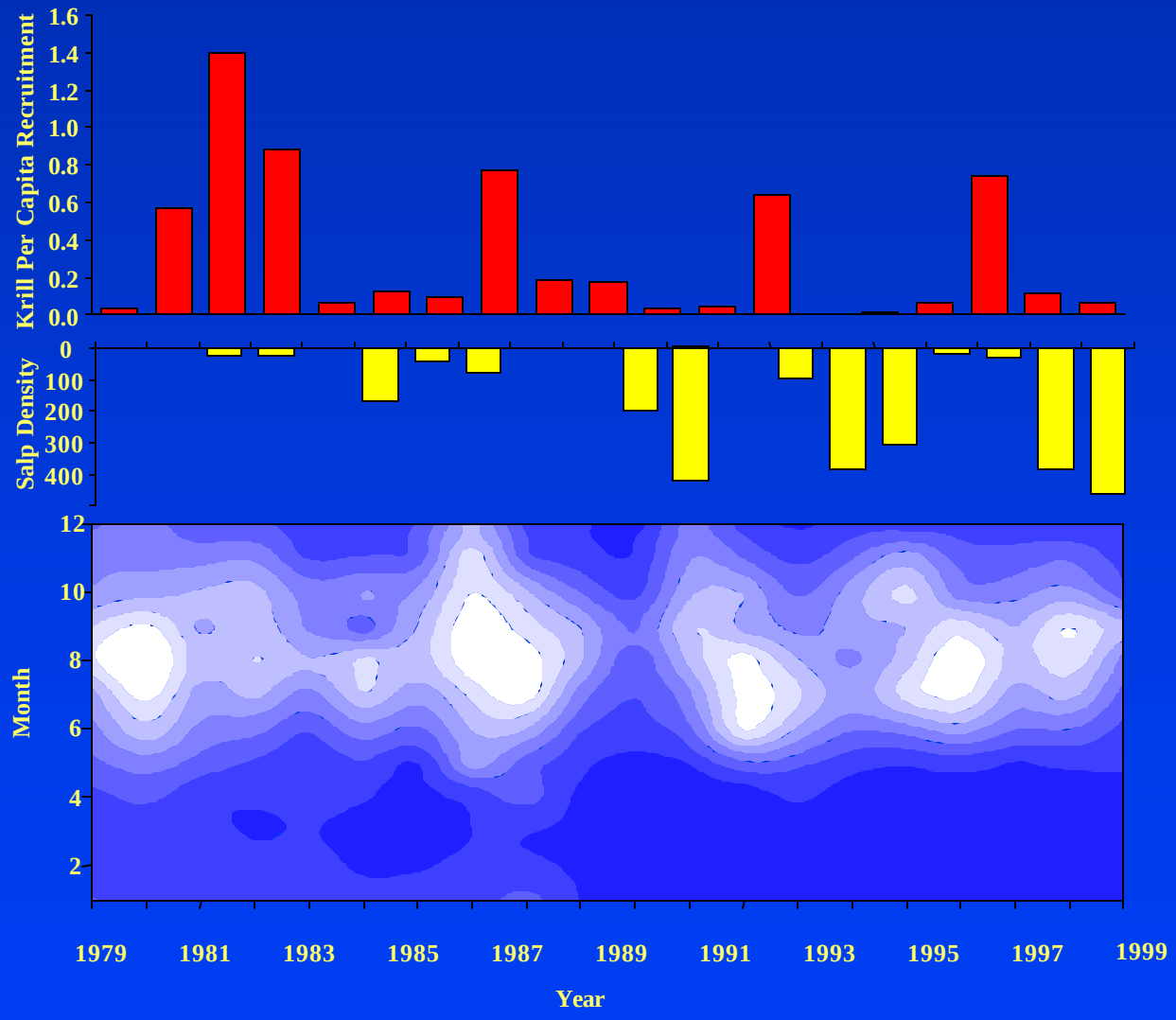
- **Member participation is voluntary**
- **Standard protocols for data collection and derivation of indices**
- **Data and indices submitted to Secretariat**
- **Prey surveys at selected sites**

US AMLR Program



- Surveys of finfish, crabs and krill in support of CCAMLR
- Long-term monitoring program in South Shetland Islands
- Ship-based surveys of krill and oceanographic conditions
- Land-based monitoring of predator foraging ecology and reproductive performance
- Working hypotheses
  - Availability of krill is affected by both physical and biological aspects of their habitat
  - Land-breeding krill predators respond to variations in the availability of their prey

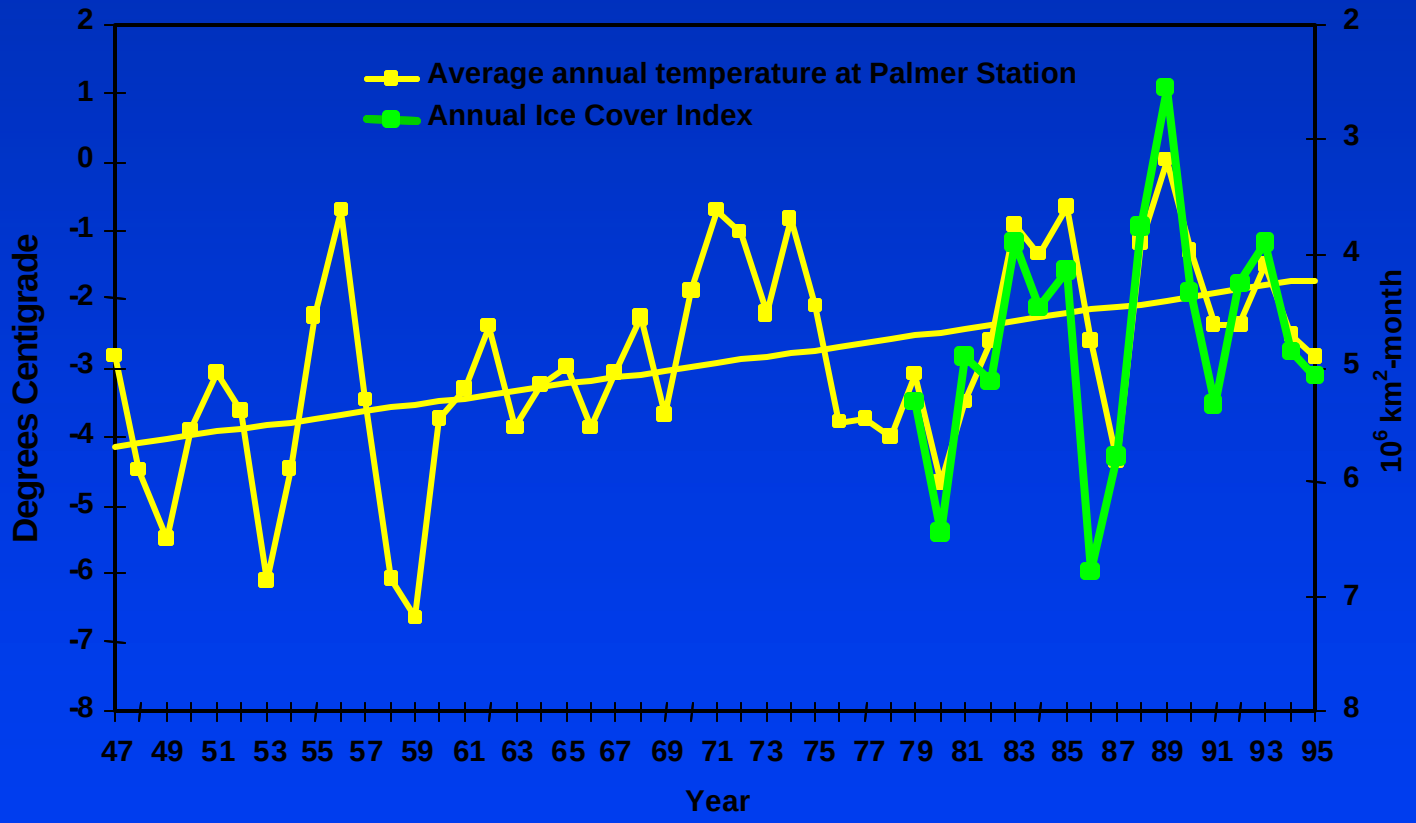
What controls krill recruitment



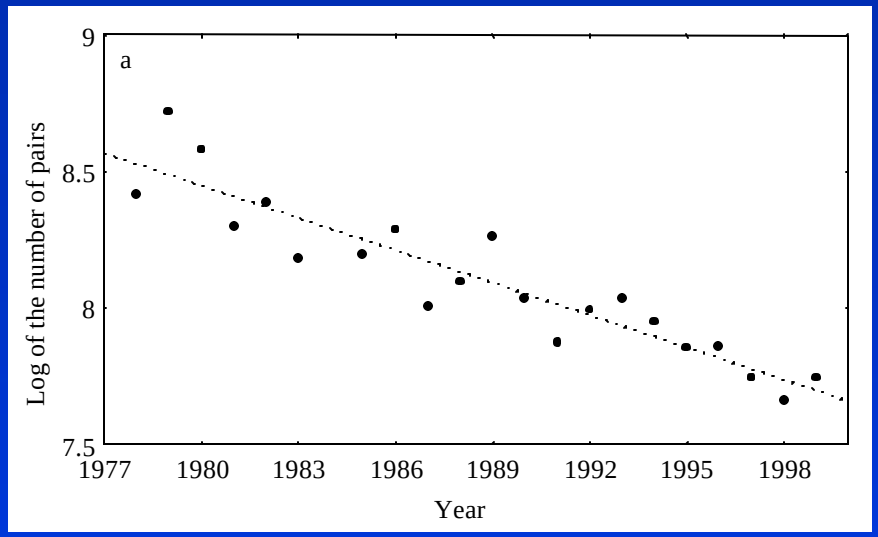
Strong year class results from:

- Good over-wintering conditions for adult krill
- Early and repeated spawning
- Slow salp population growth during spring
- Good survival of larvae through first winter
- Associated with extensive winter sea ice development

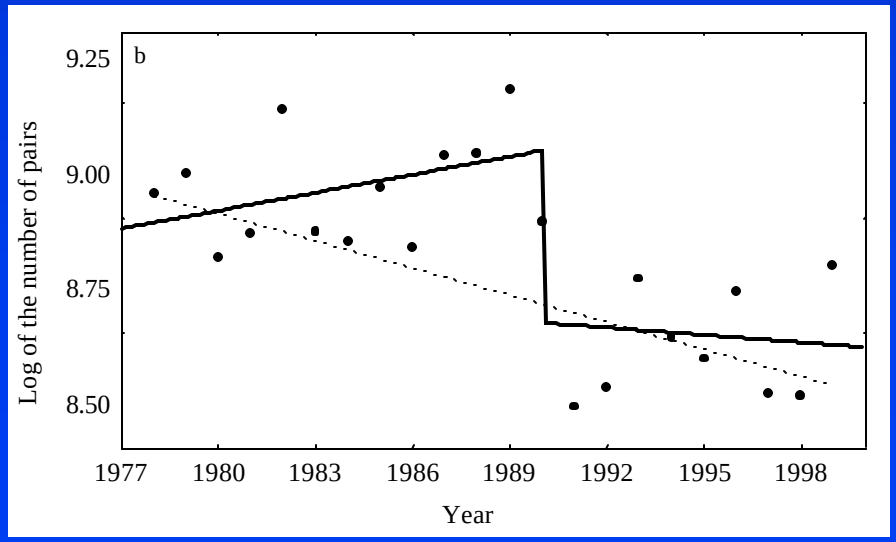
Environmental change may impact yield



Declines in penguin breeding pairs not directly correlated with krill recruitment



Monotonic decline for chinstraps

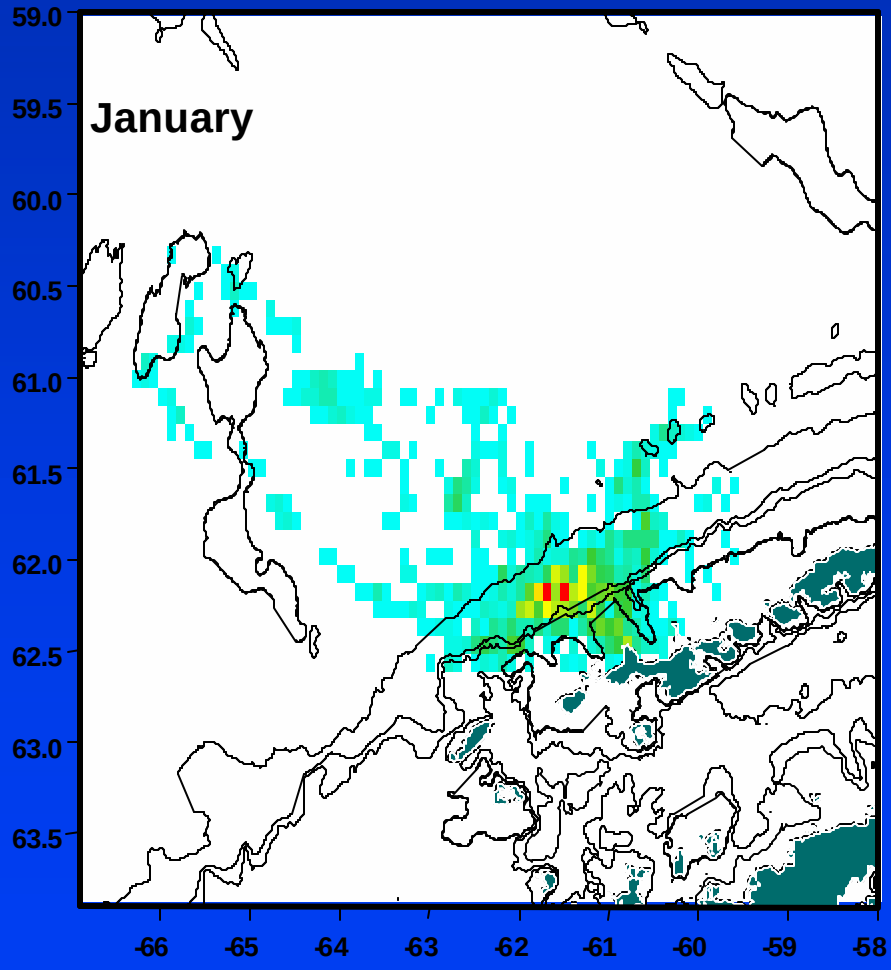


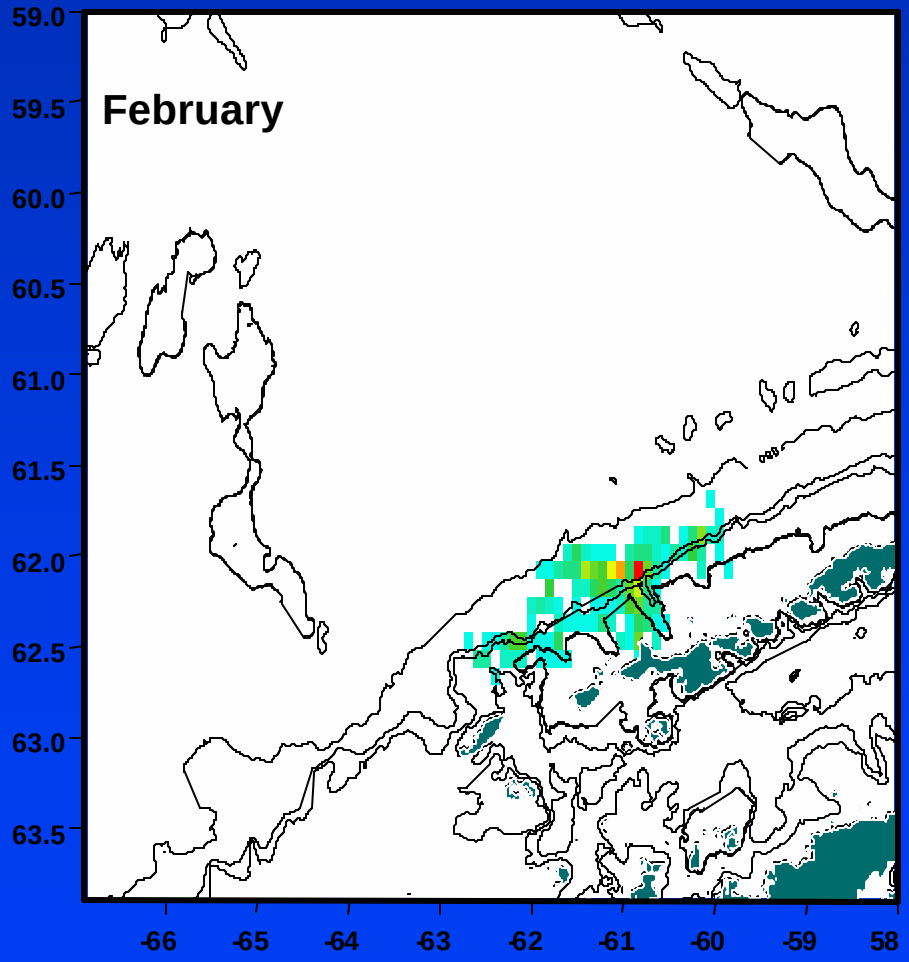
Drop in late 1980's for Adelies

Wayne and Sue Trivelpiece

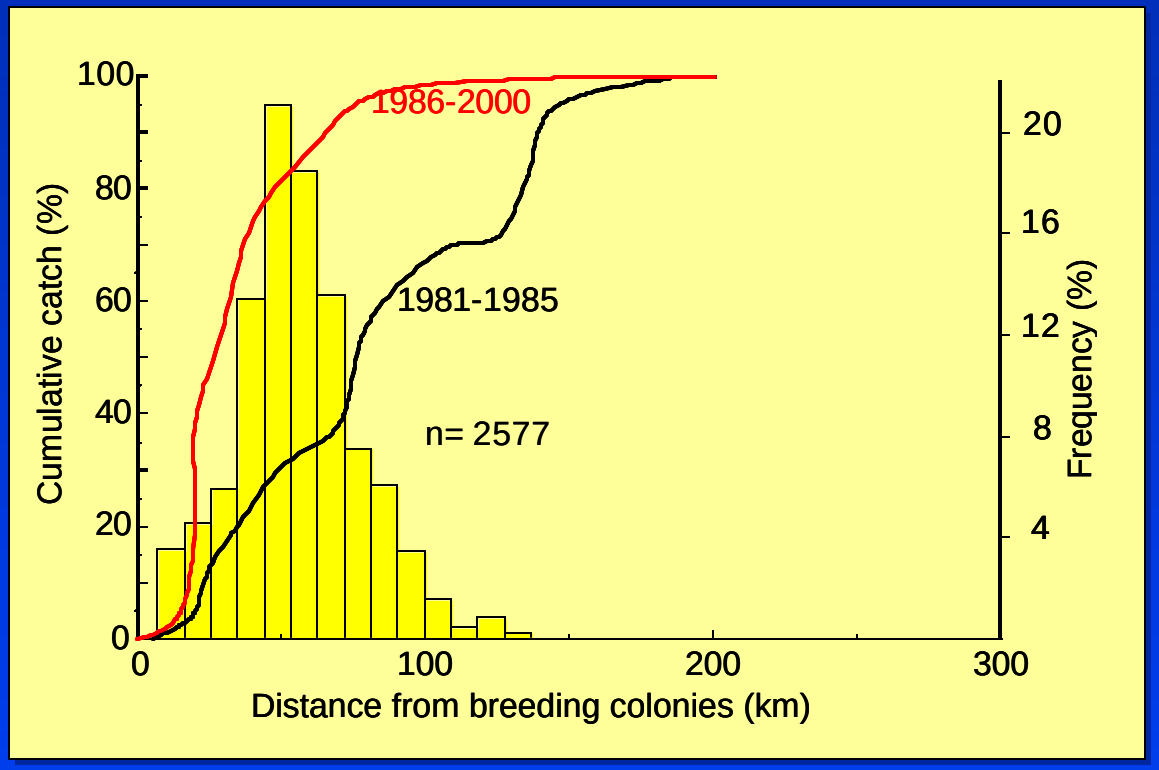
Knowledge of predator fishery overlap

Antarctic Fur Seal Distribution





Proximity of fishing and foraging to breeding colonies

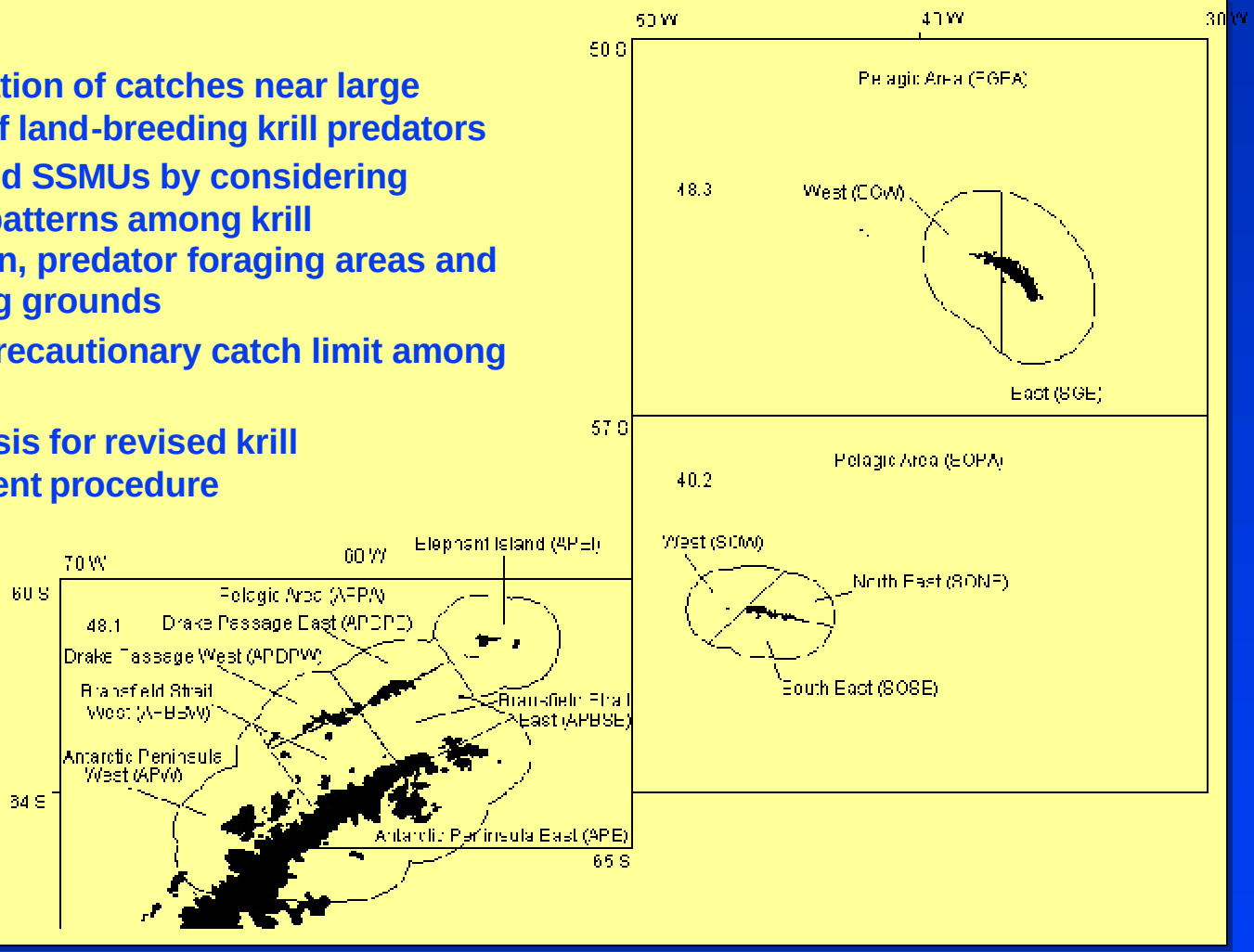


CCAMLR Secretariat

Mike Goebel

Allocating catch to Small-Scale Management Units

- Concentration of catches near large colonies of land-breeding krill predators
- Established SSMUs by considering common patterns among krill distribution, predator foraging areas and krill fishing grounds
- Allocate precautionary catch limit among SSMUs
- Spatial basis for revised krill management procedure



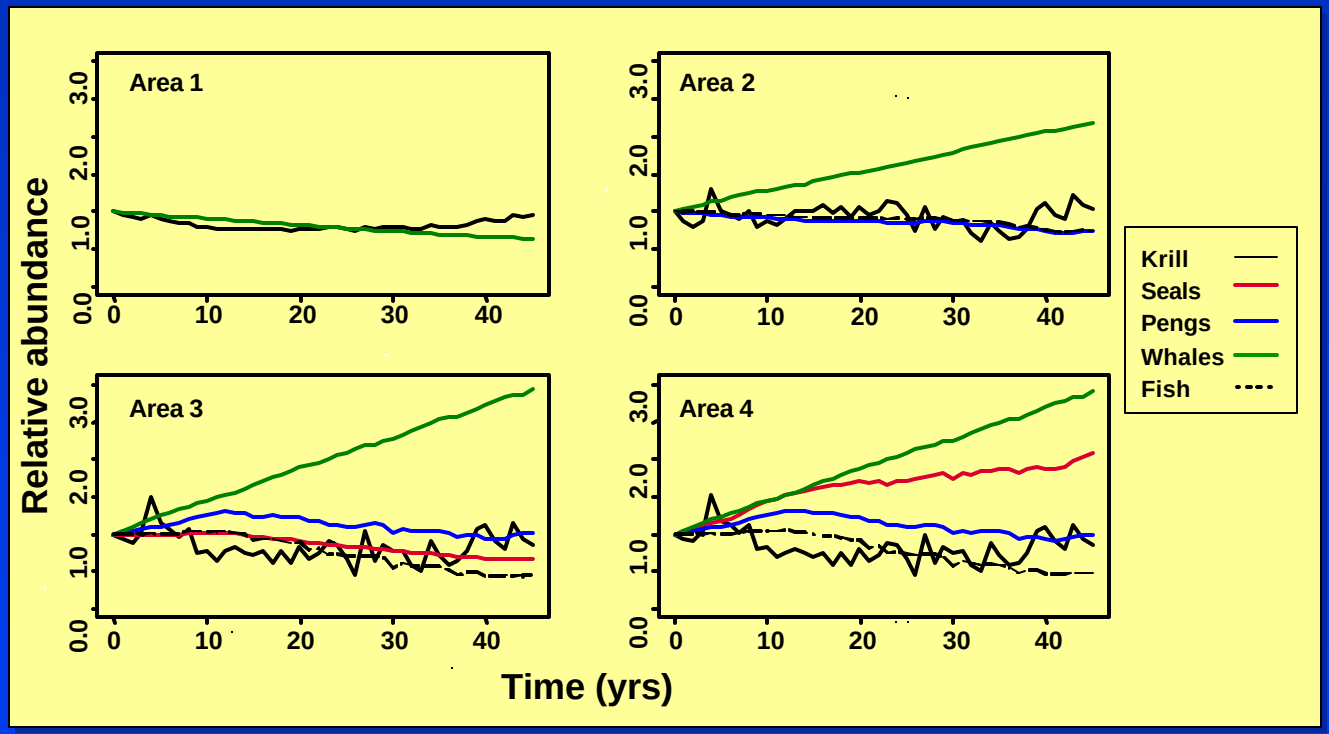
Allocating catch in SSMUs

Build Krill predator fishery ecosystem model (KPFM)
- examine likely effects on krill and predator populations as well as fishery

- **Performance of 6 different allocation schemes**
- **Spatially resolved (16 areas)**
- **Transport of krill b/w SSMU (annual scale)**
- **Coupled - Delay difference model**
- **Growth / recruitment / reproduction of predator (W, P, S)**
- **Competition b/w fishery and predators**

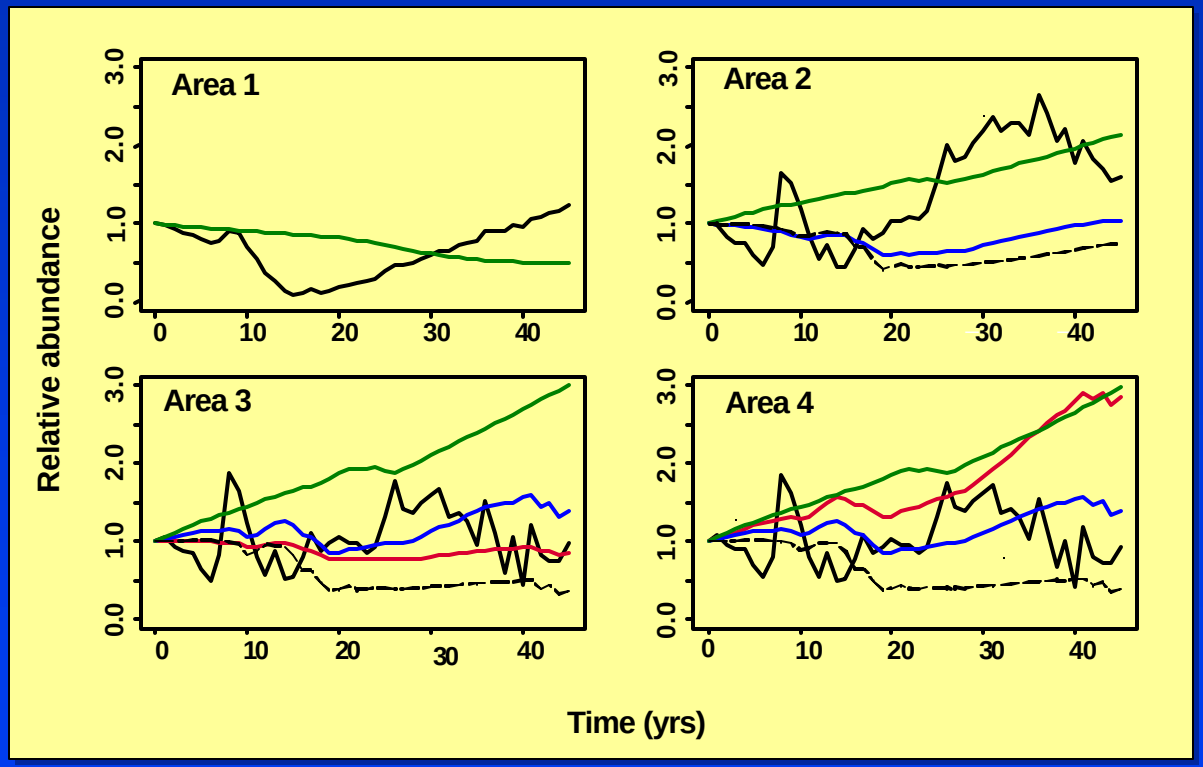
Allocating catch to Small-Scale Management Units

Random krill recruitment no fishery



Allocating catch to Small-Scale Management Units

- Random krill recruitment
- Fishery for 10 years



Ecosystem monitoring and management strategy

- **Define management objectives**
  - Viability of krill population, adequate prey for krill predators
  - Ecosystem stability, diversity, target population levels
- **Identify critical processes**
  - Those that control krill recruitment and transport, predator population growth
  - Those that control larval transport/survival, habitat extent/quality, technological/economic development
- **Define proxies for indexing processes and determine their statistical behavior**
  - Sea ice extent, zooplankton constituents, predator reproductive performance and juvenile survival
- **Elaborate management actions triggered by critical values of process indices**
  - TAC adjusted depending on expected recruitment of age-1 krill, as indexed by combination of environmental and biological factors
  - Distribution of fishing effort adjusted depending on availability of krill to predators, as indexed by hydrographic indicators of krill transport and measures of the timing and intensity of krill spawning
- **Research and development**
  - Monitor performance of management system
  - Reduce measurement uncertainty
  - Describe key processes, indices and their behavior
  - (e.g. pelagic production in the spring, regulation of penguin population growth)